61
4

United States Department of the Interior, Douglas McKay, Secretary
Fish and Wildlife Service, John L. Farley, Director

Fishery Leaflet 412

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS
OCT 19 1953

Washington 25, D. C. June 1953

MENHADEN INDUSTRY — PAST AND PRESENT

By Charles F. Lee[1/]

Contents

	Page
Abstract	1
Introduction	2
The Federal Government and the Menhaden Industry	2
Let's Meet the Menhaden	3
Early History	4
Early Development of the Menhaden Oil Industry	4
Comparison of Early and Modern Menhaden Plants	5
Economic Comparison of Past and Present-Day Plant Operations	9
Geographic Shifts in the Importance of Menhaden Fisheries	9
Fishing Methods	12
Uses of Menhaden--Then	14
And Uses of Menhaden--Now	15
Future of the Menhaden Industry	16

ABSTRACT

The year 1951 could be the centennial of the founding of the menhaden industry. The film "Story of Menhaden," and other recent publicity has enlightened the public to an unusual degree concerning the present-day status of this, heretofore, little known industry, but even those people closely connected with the menhaden fishery know little of its early history and development. The industry has come a long way in the century since its birth in New England. A little known memoir by G. Brown Goode on the menhaden industry prepared in 1877,

1/ Chemical Engineer, Fishery Technological Laboratory, Branch of Commercial Fisheries, U. S. Fish & Wildlife Service, College Park, Maryland.

NOTE: Reprinted from the Fish Meal and Oil Industry International Yearbook, Vol. IV, No. 4, p. 12 (March 1952).

just 5 years after the United States Commission of Fish and Fisheries was created, supplies material for a review of its early history. A contrast and comparison of plants, fishing methods, locations of fishery, and uses of the products of the industry as it was in 1875 with the industry of 1950 is included to highlight the progress made in the last decade.

INTRODUCTION

The menhaden industry has come into its own in the years 1949 and 1950, since vitamin B_{12} was discovered to be an important constituent of the so-called animal protein factor. This is present in menhaden and other fish meals whose importance as a feedstuff ingredient was again emphasized.

Publicity about the industry has also included a nation-wide radio broadcast from a menhaden boat, the film "The Story of Menhaden," and a short article on menhaden in a widely read popular magazine. More people than ever now know something about menhaden, but even so, many individuals closely connected with the industry itself are unaware of its early history, development, and phenomenal growth.

THE FEDERAL GOVERNMENT AND THE MENHADEN INDUSTRY

We, of the Fish and Wildlife Service and its predecessor, the Bureau of Fisheries, have watched for years the steady development of this industry. Back in the late days of the "Roaring Twenties," the Bureau of Fisheries had a field laboratory in Reedville, Virginia. The work of this laboratory played an early but important part in the now complete shift to the use of meal as a feedstuff for poultry and swine instead of fertilizer.

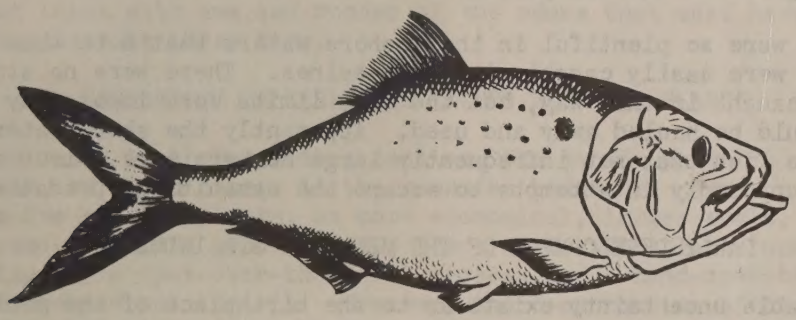
Since that time the Service laboratories have conducted several other studies of fish oil and meal. Briefly, some of these have: (1) compared the value of flame-dried and steam-dried meal for feeding heifers; (2) determined the value of menhaden oil as an antirachitic supplement for poultry; (3) studied nutritive value of spoiled fish meal and its effect on the flavor of flesh and eggs when used as a feed for poultry; and (4) investigated the factors involved in the accurate determination of the oxidized oils present in stored fish meal.

Now, some twenty-odd years after the original project, we are again engaged in a research program on the basic chemistry of this very abundant fish. However, the work in 1929 was not the first occasion for interest of the Federal Government in the menhaden. In 1874, G. Brown Goode, of the United States Commission of Fish and Fisheries, sent out a 58-item questionnaire to obtain information for a "memoir" entitled, The Natural and Economic History of the American Menhaden. This is a volume of 539 pages, based in a large part on information from nontechnical observers which was often conflicting or uncertain, and contains in addition much material that seems irrelevant and repetitious by present standards. There are, for example, almost 60 pages of direct quotations from the Oil, Paint and Drug Reporter for the years 1871 and 1877 of sections on menhaden oil price and market conditions, and another 110 pages, among the Appendices which run from A to Q, reproducing the statement of most of the correspondents.

There is still a great deal of interesting material which provides a basis for an enlightening comparison of the industry of the present day with the industry as it was three-quarters of a century ago. Since this old record is not generally available, a few highlights have been selected to present in this report a picture of the industry over the years.

LET'S MEET THE MENHADEN

For readers not familiar with the menhaden, a very nonscientific description of the menhaden would be a beautiful fish with silvery, pearly scales, very similar in appearance to the herring, alewife, or small shad. Almost all have a black spot just back of the head on each side, and older fish often have a number of irregular roundish, blue-black blotches along the sides. Some fish, especially in southern areas, show a yellowish or greenish coloration around fins and tails. In size they range up to a maximum of 15 to 18 inches, although most of them are less than a foot long. Size depends on the season



THE MENHADEN, ALIAS PORGY, FATBACK, MOSSBUNKER, OLD WIFE, BONY-FISH, HARDHEAD, WHITE-FISH, BUG-FISH, CHEBOG, ALEWIFE, AND YELLOWTAIL SHAD--IN SHORT BREVOORTIA TYRANNUS--IS SIMILAR IN APPEARANCE TO THE HERRING, HAS A BLACK SPOT JUST BACK OF THE HEAD ON EACH SIDE, RANGES IN SIZE FROM 5 TO 8 INCHES, WHICH MAKE UP MOST OF THE PRSENT CATCH, TO A MAXIMUM OF 18 INCHES.

and area in which they are caught, with Southern and Gulf fish generally running smaller than in Northern waters. According to a practice of many years, pounds of fish are converted to number of fish on the basis of a unit weight of two-thirds of a pound, although most are probably not this large.

The menhaden still goes under several aliases. The names porgy, fatback, mossbunker, and old wife are used by the fishermen in various sections. To these names might be added: bony-fish, hardhead, white-fish, bug-fish, chebog, alewife, and yellowtail shad; all in use in one part or another of their range at one time or another. All refer to the same fish--Brevoortia tyrannus--the menhaden. Ichthyologically speaking, four species are now recognized along our coast: two in the Atlantic waters and two in the Gulf of Mexico, with B. tyrannus being the more common Atlantic species and the closely related B. patronus the common species in the Gulf. The other two species, distinguished chiefly by their smaller and more randomly distributed scales, are relatively

rare. A fifth species listed is based on a preserved sample in the National Museum collected at Noank, Conn., in 1874, and never reported here or elsewhere since that time, while two species reported to be found in South American waters bring the total number of species observed to seven.

EARLY HISTORY

The name, menhaden, originated with the Indian name--Munnawhatteaûg, so it is said. The meaning of the word was literally "that which manures" and the Indians were known to have used menhaden for fertilizer from before the coming of the first colonists. Reference to such use is found in colonial writings of 1621, and local use for fertilizer by Indians and colonists alike no doubt continued through the years. In 1804, the president of Yale College took note of the benefits derived from their use by farmers of Long Island and Connecticut, to replenish lands "generally impoverished by a careless husbandry." For fertilizer, the raw fish were used, eight to ten thousand being considered as proper dressing for an acre of ground.

Menhaden were so plentiful in the inshore waters that more than sufficient supplies were easily caught with haul seines. There were no statistics on the amount caught in this way, but the only limits were imposed by the number that could be hauled away and used. Apparently the shore waters so teemed with the fish that not infrequently large numbers were driven out onto the beaches, supposedly in attempts to escape the assaults of predatory species.

EARLY DEVELOPMENT OF THE MENHADEN OIL INDUSTRY

Considerable uncertainty exists as to the birthplace of the menhaden oil industry. Maine's claim is based on oil-production starting about 1850, but this would be superseded by Rhode Island's claim to a crude process of oil recovery dating back to 1812. In any case, these early operations were very small scale, crude, and intermittent. Development was slow, through such stages as the use of pressure obtained by weighting with rocks or by a lever to squeeze additional oil from the mass of fish in the big cooking kettles. Next, a tub drilled with holes was used to hold the fish under pressure, and finally in the late 1850's the recovery of menhaden oil reached the stage where mechanical screw presses with metal curbs were used. Up to this time for the most part, these operations had been a sideline of the small New England farm but with the adoption of the screw press, oil recovery first became a small factory operation.

These early developments were mostly in Long Island and Connecticut, and growth of the industry was slow until 1865 to 1870. During this period, 20 or more factories were built in Maine, and others were built in Rhode Island around Narragansett Bay. With the factory stage fully developed, adoption of the hydraulic press was rapid and during the 1870's an increasing number of larger factories began to use steam not only for cooking the fish but as power for the press, oil pumps, and the like. These modern improvements required an investment of $50,000 to $60,000, and therefore were by no means in general use. Many of the plants were still small, some representing a capital investment of but $2,000 to $3,000 with the average about $12,000 to $15,000. However, there were a large number of plants which handled a rather impressive amount of

menhaden. For the five years from 1873 to 1877 inclusive, 60 or more factories processed on an average slightly in excess of 500 million fish to produce each year 2.5 to 3 million gallons of oil and over 50,000 tons of guano (fertilizer).

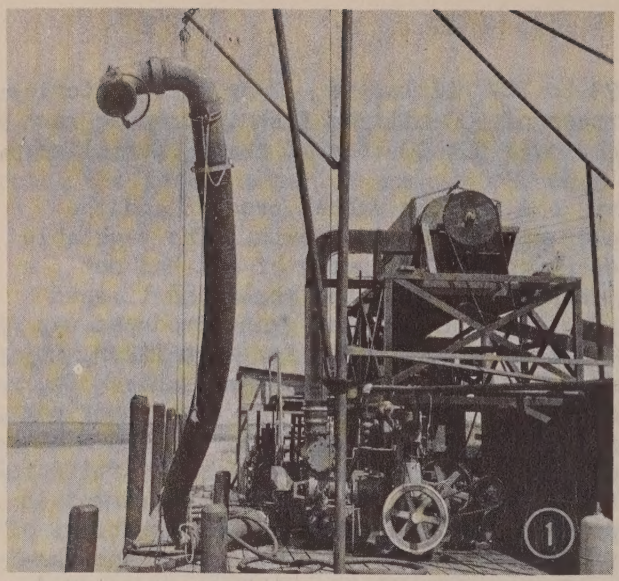
In the early days of the industry, oil was the valued product and the primary reason for the industry's development and rapid growth. The vegetable seeds and petroleum sources of our present bountiful supply of oil had not been developed and menhaden oil was a cheap substitute for whale and linseed oil in paints, lubricants, tanning, and similar uses. The guano produced was incidental, although with the previous use of the raw fish for fertilizer, it had a ready-made market within a rather restricted area near the plants. The bulk of the press cake was used wet but a very small amount was also sundried. The wet scrap was hauled away in wagon loads by nearby farmers or by the fishermen themselves as slack periods in operations permitted. Drying with artificial heat was a process known and used in Europe, but the few attempts to market an artificially dried product in this country had been failures. In operations of this nature, frequent accumulations of wet scrap were inevitable, and one cannot help but think with awe and wonder of the odors that must have surrounded the menhaden plant in those days.

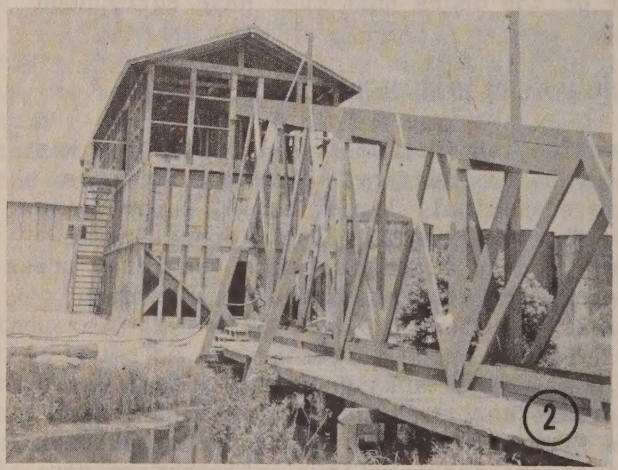
COMPARISON OF EARLY AND MODERN MENHADEN PLANTS

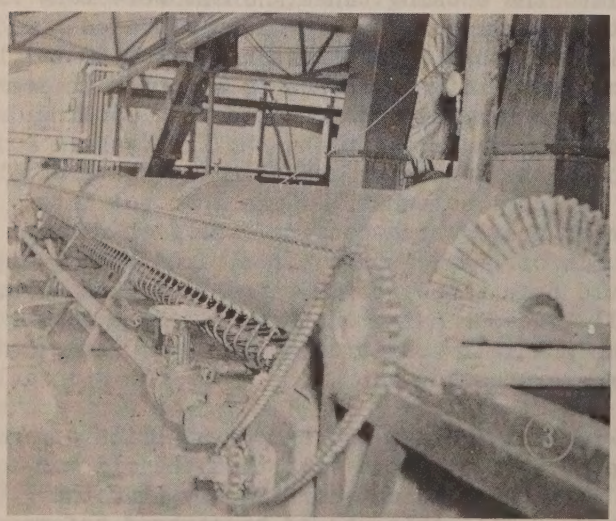
As indicated in the preceding section, the decade from 1865 to 1875 was one of growth and rapid change in the menhaden industry. Numerous failures occurred in the smaller plants, as more economical, larger scale, power-driven equipment came into more general use. There were still plants operating in which cooking was a "pot-over-the-fire" process and a hand-operated screw press was used to squeeze out the oil. However, the construction of the "modern" plant was somewhat along the following lines.

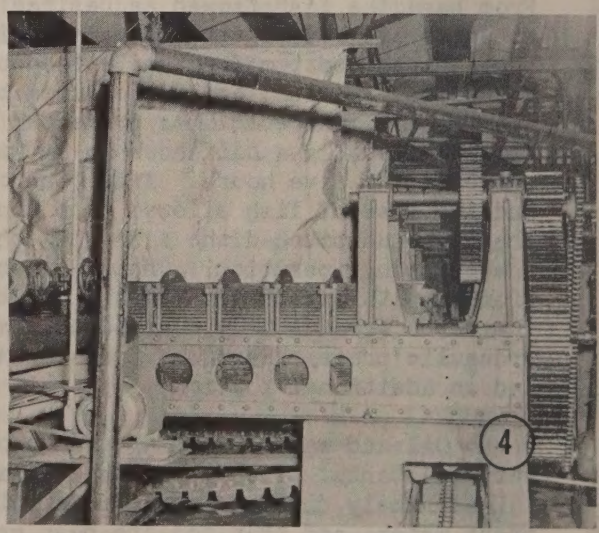
The fish were unloaded from the boats into tanks or directly into small wooden tram cars holding perhaps 20 barrels each. These cars were hauled to the upper floor of the plant where the fish were dumped into large reservoirs. From here the fish flowed as desired into the cooking tanks. These were constructed of wood staves, sometimes with a false bottom, and had perforated pipes in the bottom for the introduction of steam. The tanks held from 50 to 75 barrels of fish, and were filled to a depth of six inches to a foot with sea water, which was sometimes preheated before the fish were dumped in. Cooking time was usually a half hour to an hour, though in one plant the fish were simmered for five hours. After the cook, the hot water and oil were drawn off, and the mass of fish allowed to drain and cool somewhat. A man then got into the tank and pitched the fish into the "curbs," which confined the fish during the pressing operation. These were built of heavy wooden slats, iron bound, or of iron with eighth-inch holes, and held from three to ten barrels of fish each. The curbs were usually mounted on small trucks running on tracks leading to the hydraulic press. Here the pressure was gradually built up to 50 to 150 tons, and an additional portion of the oil was expressed.

Oil and water draining from cooking tanks and press ran to a series of settling tanks. The operators were appreciative of the fact that the oil contained finely divided fleshy material which settled out more slowly than the press water, and that for the best grade of oil, this should be removed before

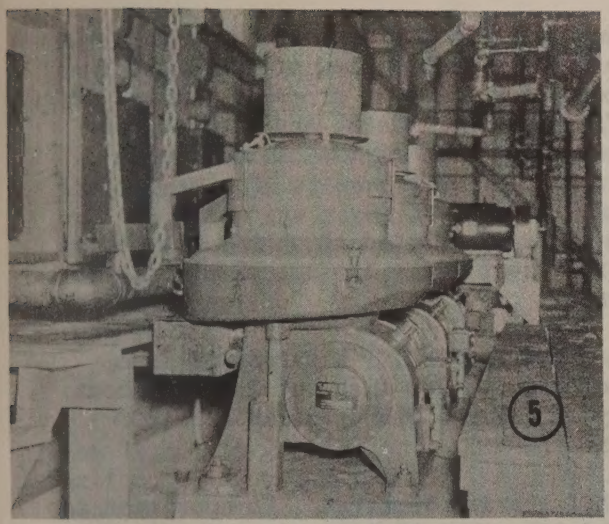


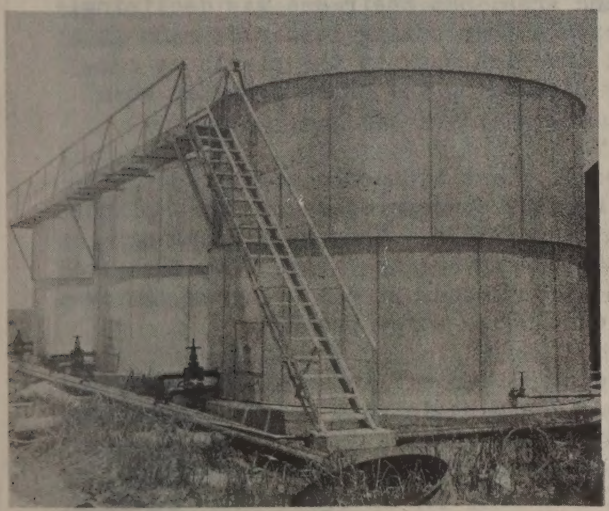


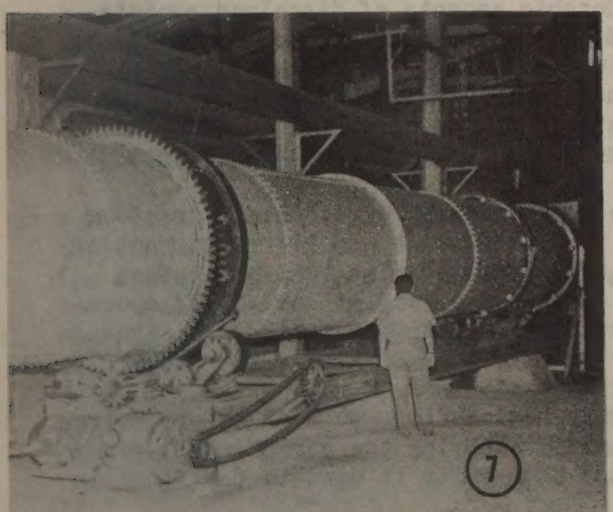




BASIC OPERATIONS OF THE HIGHLY MECHANIZED MENHADEN PLANT, WITH THE EXCEPTION OF STICKWATER PROCESSING EQUIPMENT, ARE SHOWN IN THESE PICTURES, A COMPOSITE OF PLANTS ON THE ATLANTIC AND GULF COASTS. 1. THE SUCTION PUMP AT WATER'S EDGE WHICH UNLOADS FISH FROM HOLD OF VESSEL. 2. CONVEYOR WHICH CARRIES FISH FROM PUMP TO HOLDING BINS (HOUSE IN BACKGROUND) OR DIRECTLY TO COOKERS. 3. STEAM COOKER THROUGH WHICH FISH ARE FORCED IN A CONTINUOUS STREAM BY SCREW CONVEYOR. 4. CONTINUOUS SCREW PRESS THROUGH WHICH FISH, STILL HOT, GO DIRECTLY FROM COOKER.







5. BATTERY OF CENTRIFUGES USED TO PROCESS OIL. 6. OIL STORAGE TANKS, A PROMINENT PART OF THE SCENE OF ANY MENHADEN REDUCTION PLANT. 7. HUGE DRYER IN WHICH PRESS CAKE IS FED AND WET MATERIAL REDUCED TO SCRAP. 8. DRIED SCRAP ON SCRAP HOUSE FLOOR. NOTE CONVEYOR OVERHEAD WHICH SIFTS SCRAP DOWN TO THE FLOOR TO HASTEN COOLING.

putrefaction started. However, settling and skimming were the only means available to effect this separation. The top oil was skimmed off and held in open tanks for one or two weeks to sun bleach for the best grade of "white" oil. The lower levels of oil were run off into other tanks, and yielded progressively poorer grades. Some plants used the sludge at the bottom, which could be recooked to separate "gurry" oil.

The wet presscake, or guano, in the curbs was dumped through a trap door in the floor to a room or open space beneath the plant. In some plants it was allowed to accumulate until fall or winter.

The common bulk measure of the time was a "barrel." A barrel of fish weighed about 200 pounds net, and might hold 180 to 280 fish but 250 was about the average content. The maximum capacity of a large plant was about 2,000 barrels per day, or 200 tons of round fish.

There were still a few floating fish factories on barges, in operation in 1875, on sounds and bays in the Long Island area, but their use was declining. The large "steamers," or steam-powered vessels then coming into use, made it a relatively simple and rapid matter to get the fish back to the plants as compared to the difficulties and uncertainty of landing the catch promptly when sail was the only motive power.

In comparison with that era, the modern plant is mechanized to the ultimate degree. Fish are unloaded from the hold by conveyors, or, in many plants, by large suction pumps, onto conveyors which carry them through a weighing device and directly to the cookers or to temporary holding bins. The fish are then forced through long steam cookers in a continuous stream by screw conveyors, and, while hot, go directly to huge continuous screw presses.

In some plants the press liquors are still run off to settling tanks, a procedure not unlike the earliest methods. However, in most modern plants the fines are first filtered out on vibrating screens and the filtrate of liquor-and-oil mixture goes through two batteries of centrifuges. An almost dry, clear, yellow oil emerges from the second series of centrifuges. The water phase, called stickwater, contains considerable amounts of dissolved protein and vitamins but was ordinarily discarded. However, it is now concentrated to 50 per cent solids in many plants to yield "condensed fish solubles." Most plants now have equipment of all types individually driven by electric motor rather than by steam power. This eliminates the maze of shafting and belts which is necessary for power transmission from a single central power unit.

The press cake is fed directly into large rotary, direct flame or steam driers where the wet material is reduced to "scrap" with a moisture content of six to ten per cent. Most of the driers are now fired with fuel oil rather than coal, a change which results in a cleaner, more readily controlled operation. Some plants have cyclone separators to remove fine material from the exhaust gases.

The dried scrap is piled on the "scrap house" floor to cool before being bagged. In many plants, cooling is hastened by shoving the scrap into a conveyor that carries it up to the ceiling and then sifts it down to the floor in

a fine shower. The ultimate in mechanical handling is reached by plants using small truck-tractors equipped with 'dozer blades for moving meal piles around the cooling floor.

In some plants the scrap is ground to meal, in others the unground scrap is shipped. In either case, the material is weighed into sacks automatically and the sacks are sewed by a special sack sewing machine in modern plants. Another recent innovation in the menhaden industry is the use of pallettes and special fork-hoist trucks to load the sacked scrap or meal into trucks or freight cars.

ECONOMIC COMPARISON OF PAST AND PRESENT-DAY PLANT OPERATIONS

In the early 1870's the total investment in plants and fishing vessels was less than $3 million. Oil prices ranged usually from 35 to 45 cents per gallon, while press cake or guano brought $6 to $11 per ton. The value of the oil produced was approximately $1 million annually, and an estimate of the value of the meal, based on $11 per ton, was in the range of $500,000 to $600,000. These estimates are based on an average catch of 500 to 600 million fish.

By comparison, the menhaden industry in 1950 handled almost 1.5 billion fish or about 2 1/2 times the catch of 75 years ago. Oil production was 10.2 million gallons, over three times the yield of the 1870's, due in part to more efficient oil recovery methods. Meal production of 103,365 tons was about double the amount of 75 years ago. The apparent discrepancy of a smaller proportionate yield of meal is due to the fact that the "guano" had 30 to 50 per cent water in it, instead of the 10 per cent moisture content of modern meals.

The pre-Korean war oil price had been about six cents a pound, which corresponds to about 44 cents per gallon or little more than it sold for 75 years ago, but the meal, now used almost entirely in swine and poultry manufactured mixed feeds, is sold for $125 to $140 per ton. The result of this shift in the relative importance of oil and meal has meant a change in relative value per ton, based on 100 gallons of oil for each ton of meal, from roughly 2 to 1, oil to meal, in 1875 to about 1 to 3 now. Recently released statistics show the total value of menhaden products for 1950 to be slightly less than $19 million, even with the low price for oil that prevailed for most of the year.

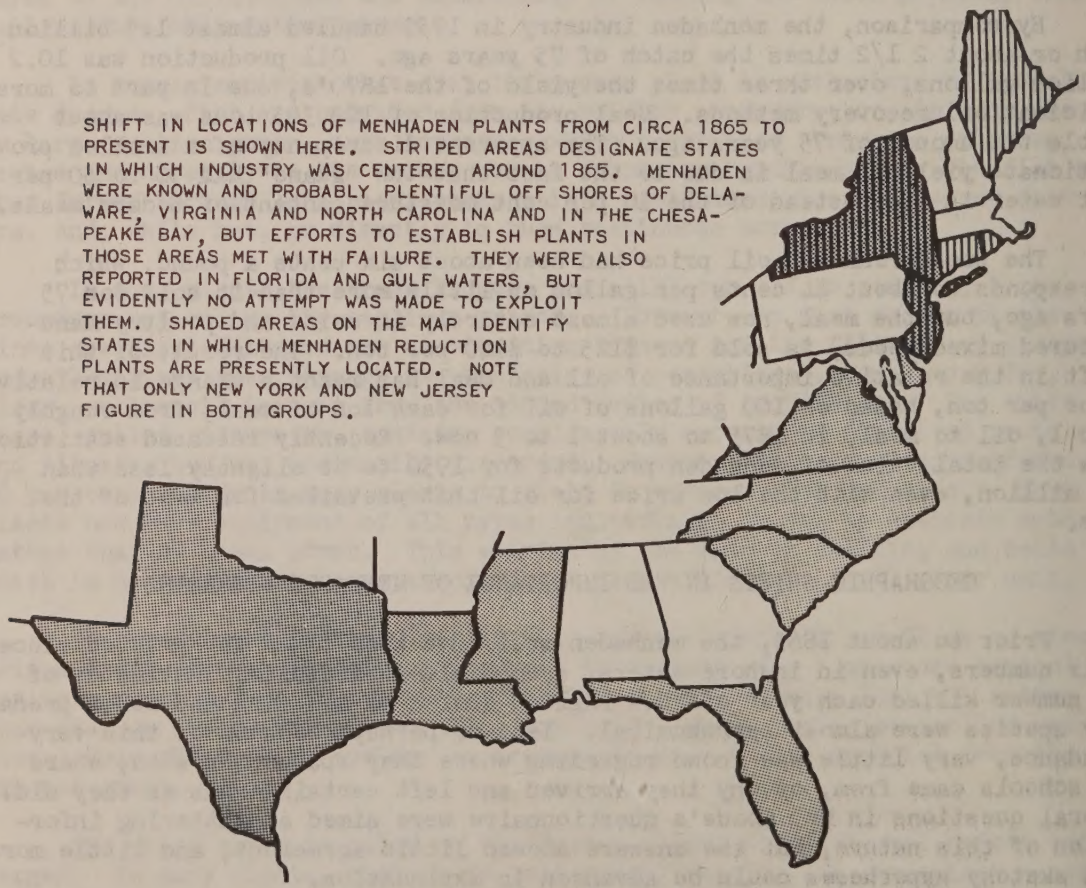
GEOGRAPHIC SHIFTS IN THE IMPORTANCE OF MENHADEN FISHERIES

Prior to about 1865, the menhaden must have been taken for granted since their numbers, even in inshore waters, seemed almost infinite. Estimates of the number killed each year off New England shores by bluefish and other predatory species were almost astronomical. Yet, or perhaps because of this very abundance, very little was known regarding where they spawned or when, where the schools came from, or why they arrived and left certain areas as they did. Several questions in Mr. Goode's questionnaire were aimed at gathering information of this nature, but the answers showed little agreement, and little more than sketchy hypotheses could be advanced in explanation.

At that time the menhaden industry centered in Maine, with Rhode Island, Long Island, Connecticut, and New Jersey following in about that order of importance. Menhaden were known, and probably were plentiful off the shores of Delaware, Virginia, North Carolina, and in the Chesapeake Bay, where they were caught in traps and seines used in fishing for other species, but several attempts to establish factories in these areas had met with failure.

Mention was made of the presence of menhaden in the St. Johns River in Florida and in the Gulf, but, in general, only fragmentary information was available from Southern areas. All evidence indicates that at that time, 1870 to 1875, the greatest concentrations of menhaden were to be found off the New England coast during the summer months.

In contrast, at present menhaden are taken in the New England trap fishing but not in numbers sufficient to support even one reduction plant. New York represents the northern limits of the present menhaden meal and oil industry. New Jersey, Delaware, and Virginia plants usually handle about half of the total catch. North Carolina has eight reduction plants in the Beaufort-Morehead City area. The Florida north coast, once an important processing



SHIFT IN LOCATIONS OF MENHADEN PLANTS FROM CIRCA 1865 TO PRESENT IS SHOWN HERE. STRIPED AREAS DESIGNATE STATES IN WHICH INDUSTRY WAS CENTERED AROUND 1865. MENHADEN WERE KNOWN AND PROBABLY PLENTIFUL OFF SHORES OF DELAWARE, VIRGINIA AND NORTH CAROLINA AND IN THE CHESAPEAKE BAY, BUT EFFORTS TO ESTABLISH PLANTS IN THOSE AREAS MET WITH FAILURE. THEY WERE ALSO REPORTED IN FLORIDA AND GULF WATERS, BUT EVIDENTLY NO ATTEMPT WAS MADE TO EXPLOIT THEM. SHADED AREAS ON THE MAP IDENTIFY STATES IN WHICH MENHADEN REDUCTION PLANTS ARE PRESENTLY LOCATED. NOTE THAT ONLY NEW YORK AND NEW JERSEY FIGURE IN BOTH GROUPS.

center, has had five or six poor years but did very well in 1951. The Gulf Coast, until recently almost unexploited, now has two centers of production: one in the Louisiana-Mississippi region and another, the most recently developed, in Texas.

In view of this radical geographical shift of the populations of menhaden towards the central Atlantic and Gulf Coasts, it should be noted that in 1870 there was already evidence of this change. Prior to 1860, menhaden were apparently quite common in the Bay of Fundy and on the shores of New Brunswick, but in the next decade they were rarely found in large numbers east of the Booth Bay area in central Maine. According to more recent references on the menhaden, the fish disappeared from the waters north of Cape Cod as early as 1879. As a result, the Maine companies, after a few years' struggle, moved south or went broke. Then, for a period after 1900, menhaden were again relatively plentiful off the Maine coast, but this was a temporary situation so uncertain that few plants ever relocated in the area. In this connection, it is interesting to note that menhaden were plentiful in Maine waters in 1949, but it was only a one season stand. They did not come back in 1950.

Then, as now, as the waters warmed up in the spring, schools of menhaden put in their appearance at progressively later dates in areas in succession of the north and east. This process was reversed as the shore waters cooled in the fall, and led to the not unnatural, and still generally held, conclusion that a single huge population gradually spread out along the coast under the influence of rising water temperatures. If this is accepted as true, how can one explain the fact that few menhaden now go north of Long Island? There is some evidence, in rate of recession of glaciers, that the world climate is gradually warming up. While this is difficult to prove, there most certainly has not been an invasion of cold water sufficient to account for these radical changes in migratory habits.

Apparently there are still many unanswered questions as to the life history and migratory habits of the menhaden. The sudden appearance of large schools is so strange that there was once credence given the idea that they hibernated during the winter in the bottom mud, to pop up--like crocuses--when the weather warmed up. The recent great fluctuations in abundance in restricted coastal areas are most readily explained by the theory that each of the major centers of the coastal menhaden industry is based upon semi-independent population, each reacting in its own way to certain unknown biological and ecological factors determining their year to year abundance.

One proof was present years ago, that there were at least two populations. When Goode wrote his report, as much as 70 per cent of all menhaden caught south of Delaware Bay were said to have been afflicted with a commensal organism. This "bug," hence the name bug-fish, bore the scientific name of Oleucira praegustator, and was (or is) a relative of the ordinary pill bug, order Isopoda. It was not a true parasite, but rather, like the oyster crab, was just along for the ride. It clung tenaciously, head foremost, just inside the menhaden's mouth. In some cases, these so-called parasites reached a length of as much as two inches, and must very nearly have blocked the throat passage of victimized fish. The hosts were not apparently harmed, however, as the afflicted fish were said to be as fat as those unafflicted. Our interest

in it lies in the fact that fish with the "bug" were never observed north of a sharply demarked area. It seems impossible that the same population was involved in both northern and southern waters. There are certainly no environmental conditions which could lead to such a sharp division between fish, 70 per cent of which carried the commensal organism, and those completely unafflicted.

FISHING METHODS

Prior to 1860 or 1865, haul seines or gill nets caught all the menhaden that could be used. As oil factories sprang up along the coast, the much greater fishing intensity soon drove the fish from shore waters, and it has been largely a sea fishery ever since. At first, boats were predominantly sail. In 1873, there were 383 sail vessels engaged in catching menhaden, but the number of steam-powered vessels gradually increased. The "steamers" were usually of about "60-ton burden," but except for size they did not differ greatly from the present menhaden boats. Most modern boats are powered by diesel engines, and have other modern improvements and conveniences--2-way radio phone, recording depth indicators, and even scouting airplanes--but fundamental fishing methods have changed hardly at all in 75 years. The same purse boats, now power-driven, the same "striker," the tom weight and the purse seine, the same crew tugging the net hand-over-hand into the boats, probably singing the same chanteys, are in striking contrast to the changes occurring in other

TREND IN POWERING OF MENHADEN BOATS IS EXEMPLIFIED IN THIS VETERAN VESSEL, WHICH WAS STEAM PROPELLED UNTIL 1938 AND THEN CHANGED TO DIESEL POWER

PART OF THE MENHADEN FLEET AT BEAUFORT, N. C., A CENTER OF MENHADEN OPERATIONS

FUNDAMENTAL FISHING METHODS HAVE CHANGED LITTLE IN THE MENHADEN FISHERY IN THE PAST 75 YEARS. ABOVE VIEW OF THE CREW TUGGING THE NET HAND-OVER-HAND INTO THE PURSE BOATS, PROBABLY SINGING THE SAME CHANTEYS AS THEIR GRANDFATHERS, IS IN STRIKING CONTRAST TO THE CHANGES OCCURRING IN OTHER PHASES OF THE INDUSTRY. AT RIGHT, FISH ARE TRANSFERRED FROM SEINE TO HOLD OF MOTHER BOAT. THIS OPERATION CAN BE DONE WITH SUCTION HOSE.

phases of the industry. Net sizes are even within the same general range, about 200 fathoms long, though probably somewhat shallower than the 15 to 20 fathoms that once were popular, and meshes now may be 1 3/4 inches rather than 2 1/2 to 3 inches once used. This no doubt reflects the somewhat smaller average size of the fish that now make up the bulk of the catch in most areas.

A nostalgic note is struck by the following estimate of the daily cost of operating one of the "large" steamers in 1877. Coal consumption was about one ton per day, and cost, including oil and wages for the engineer, was said to be $8 daily. The fishermen supplied their own provisions and worked shares, and, to quote, "live probably the most extravagantly of any class of fishermen, and in some cases go into foolish expenditures for the table." There were "instances of it costing them $10.00 per week for provisions alone . . . $4.00 would be nearer the (average) figure."

USES OF MENHADEN--THEN

Three-quarters of a century ago all of the menhaden scrap, wet or crudely dried, was used for fertilizer and was better for the purpose than the raw fish had been, since the oil had been an undesirable addition to the soil. In spite of the fact that quite extensive animal feeding tests in Europe of similar animal protein concentrates had already proved their value for growth, and milk or meat production, it was more than 50 years before the trend from fertilizer to feed was under way in this country.

Menhaden oil was the main product of the processing factories, although oil recoveries were low by present-day standards. It was thoroughly appreciated, even then, that the oil content of fish varied widely, and size of fish, season of catch and locality of the catch all affected oil yield. Prices for raw fish were in many cases adjusted according to the oil yield. Maine fish in late summer were the best catch. The grades of oil marketed are informative as well as descriptive. Top grade was "select, light strained," then "select light," "choice brown," "inferior to dark," and "gurry."

Menhaden oil was chiefly used, "as substitute for the more costly and popular oils, and to adulterate them." Petroleum base, or mineral, oils were produced in very small amounts, and the vegetable sources such as cotton-seed, corn, and soy beans, which now yield such a large volume of oil, were unexploited. Whale oil had been a basic supply, but was already becoming scarce and high priced. Consequently, menhaden oil was used mixed with mineral oil as a burning oil in miner's lamps, and even as a lubricant for machinery. (Shortages must have been desperate, indeed.) Other uses were more orthodox; it was used extensively in leather tanning, rope making, and in paints. Mixed with whale oil it was sold as whale oil! Oil, Paint, and Drug Reporter of 1874 implies that most of the whale oil sold was two-thirds menhaden, in fact, "one concern alone sells more 'winter bleached whale oil' than is caught of crude, and they do not by any means get all the crude." Apparently, in those days anything you could put over on an unsuspecting public was perfectly legitimate business.

At present, virtually all menhaden caught are reduced for oil and meal. Formerly, menhaden were used for other purposes to a considerable extent, and

some of those uses are interesting historically. Chief among the uses of fresh menhaden was for bait. In these days of power-driven trawlers and draggers it is often forgotten that not so long ago almost all ground fishing was line-fishing. To catch cod, pollock, haddock, or halibut, fishermen had to have bait. By some accounts, it seemed as if they took better care of their bait than they did of the catch. Some fishermen iced down the bait much as trawlers ice fresh fish now, while others "slivered" the menhaden and salted them in kegs. The description of "slivering" shows it to be nothing less than a filleting operation, and so perhaps one of the earliest uses for fillets was as bait.

Menhaden were also used as mackerel bait, for which purpose they were ground up and used for chum, or "toll-bait" as it was then called. Menhaden were so good for mackerel bait that Canadian fishermen imported large quantities after the menhaden left their coasts, and there were international hearings in 1868 to 1870 regarding the hardship imposed by tariffs on menhaden bait. It was estimated that in 1877 bait equivalent to 80,000 barrels of round fish or 26 million menhaden were used for this purpose.

In addition to its use as bait, both fresh and salted menhaden were eaten. They were also canned in oil to produce "sardines." If we are to believe Mr. Goode, menhaden "when perfectly fresh . . . are superior in flavor to most of the common shore fishes, but if kept they soon acquire a rancid and oily flavor." Near Newburyport, Mass., under the name of "hard-head shad" they were "considered more palatable than the early run of river shad." In Washington, D. C., in the fall and winter "strings of 'alewife' . . . met . . . with a ready sale at 40 cents a string, a price nearly as high as that of striped bass, the favorite fish in Washington." In some localities in New England late-caught fish were salted or smoked for home use, while poorer quality fish were salted and shipped to the West Indies and Guiana.

One enterprising gentleman even packed menhaden in spices and vinegar and sold them under the guise of "Shadine," "Ocean Trout," and "American Club-fish," while another, the Hon. S. L. Goodale, promoted with great enthusiasm a "concentrated extract of the juice of the flesh" of the same ubiquitous fish. This product, which sounds like our own "condensed fish solubles," was said to be very similar, in fact "in all respects, equal to the best Leibig's extract of beef." In view of the present low esteem in which menhaden is held as a food fish, this former use for the table is difficult to understand, especially since other species, such as bluefish, now highly prized as food, were apparently very plentiful in those days.

AND USES OF MENHADEN--NOW

Menhaden meal, with other fish meals, is now highly esteemed as a source of high quality protein, minerals, and vitamins, and all that is produced goes into swine or poultry manufactured mixed feeds. It is one of the more expensive ingredients and as such is rarely used in excess of five per cent of the ration. Menhaden fish solubles are used in much the same way as the meal, alone or with fish meal, as a protein and vitamin supplement.

Menhaden oil, which now accounts for almost half of the total fish body

oil production in this country, is competitive not only with other fish oils but with vegetable drying oils and animal stearine sources as well. However, menhaden oil has, or can be given by cold pressing, heat bodying and other treatments, special properties which make it valuable for a wide variety of uses. As a drying oil it goes into special paints, varnishes, linoleum, inks, putties, caulking compounds, brake blocks, and many other products. The stearine faction, which amounts to about 30 per cent of the oil, goes mostly to soap stock, though small amounts are refined for use in cosmetics and pharmaceuticals.

FUTURE OF THE MENHADEN INDUSTRY

We have looked into the past century in order to see the menhaden industry as it was in its infancy some 75 years ago. Comparison with the industry as it stands today has emphasized the great progress that has been made, and the manner in which the industry has kept in step with the technological developments of recent years. Aided no doubt by generally good prices for meal, and occasional very profitable oil prices, the industry has in very recent years expanded and modernized, replacing antiquated equipment and methods.

As a result of this expansion and modernization the menhaden catch has been increased almost 50 per cent over the previously roughly normal figure of two-thirds billion pounds, in an effort to meet this increased capacity. While little has been said about catch as related to fishing efforts in the menhaden fishery, the impression is received quite frequently that plants are not operating at or near their maximum capacity because they are unable to get the menhaden. Plant owners have indicated that their share of the billion pound catch has been hard come by, with long trips and days of fruitless searching in some instances.

Perhaps fishing has always been so, alternate good times and poor, as luck favored or frowned on each fleet or production center, so that these circumstances may not be cause for alarm. Or perhaps, the fishery has approached close to its maximum yield. In spite of extreme local fluctuations in abundance, so far as is known, at no time in its existence has the menhaden fishery as a whole failed to the same extent that the pilchard fishery did just a few years back, or as has the herring and sardine fishery at intervals and in some areas throughout the world.

From the vantage point of 75 years of generally successful fishing, the dire predictions made in the 1870's of ruin to the industry from overfishing or by predatory species may seem amusing. However, the industry did fail, and has disappeared from Maine, Rhode Island, Massachusetts, and Connecticut in turn. Increases in other areas have, heretofore, more than compensated for these lost production centers, but future trends are impossible to predict.

More extensive knowledge of the menhaden's life history, spawning areas, factors affecting movements of schools, and particularly factors affecting growth and abundance would appear to be most desirable. Efforts to enlarge on our biological knowledge of the species should not be delayed until its virtual disappearance, as in the pilchard fishery, on the assumption that, since it never failed, it never will fail. It could happen here!

In the meantime, continued progress of the menhaden industry depends on the best utilization of the menhaden products now produced, exploration of every possibility for the development of new products from menhaden, and upon the background of information necessary to meet the claims of competitive products. As a means toward this end the Fish and Wildlife Service has instituted the earlier mentioned program of research into the basic chemistry of menhaden and menhaden products.

INT.-DUP. SEC., WASH., D.C. 46820